Process and Supporting Tools
for
Conducting
Technology Readiness Assessments

30 Apr 04

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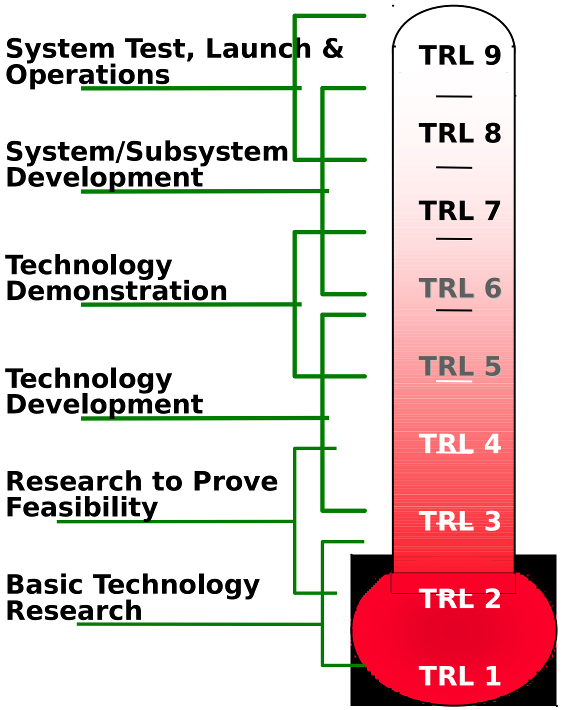
AFRL/AE

Briefing Outline

- Tech Readiness Assessment (TRA) vs Tech Readiness Level (TRL)
- Candidate TRA process
- Supporting Tools
  - TRL Calculator – a 1st Start
  - Systems Engineering Based TRA Tool
- Summary

TRL Scale
Current Driver For TRAs



Technology Readiness Levels (TRLs)

9. Actual system "flight proven" through successful miss operations
8. Actual system completed and "flight qualified" throug and demonstration
7. System prototype demonstration in a operational envi
6. System/subsystem model or prototype demonstration relevant environment
5. Component and/or breadboard validation in relevant environment
4. Component and/or breadboard validation in laboratory environment
3. Analytical and experimental critical function and/or characteristic proof of concept
2. Technology concept and/or application formulated
1. Basic principles observed and reported

Subjective and Incomplete

TRA >> TRL

Documented TRA Criteria

- **Tech Readiness Level (TRL)**

Current: Performance Driven

Customer Needs Set Con

Example TRA Elements

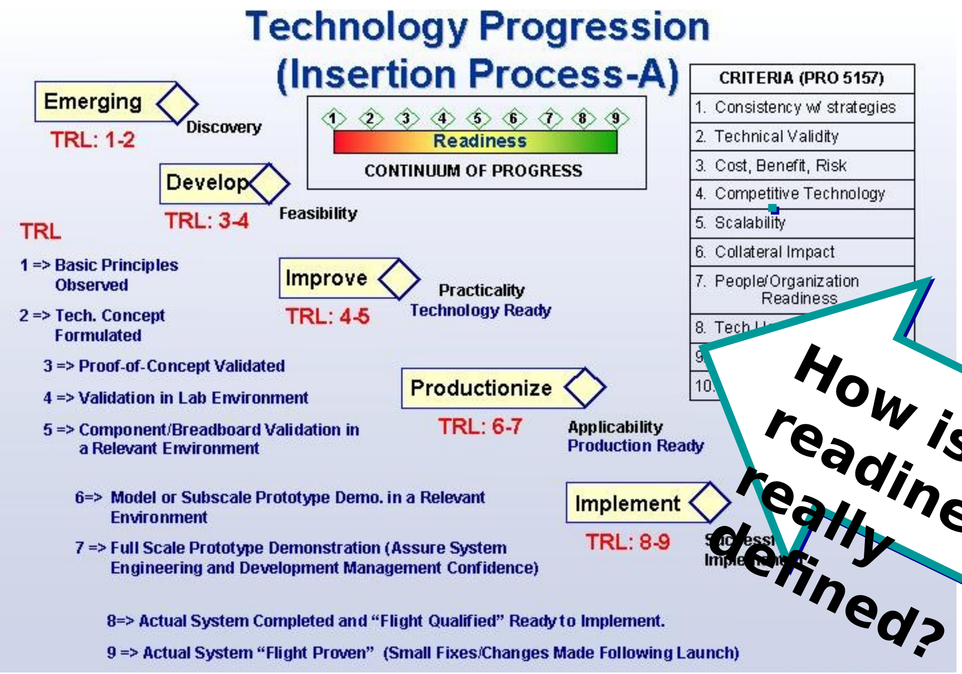
- **Performance (TRL)**
- **Design Maturity**
- **Producibility**
- **Industrial Base Capability**
- **Maintainability**
- **Parts obsolescence**
- **Survivability**
- **Sustainability**
- **Schedule**
- **Costs**
- **…**

However, Many Other Factors Influence The "Readiness" of a Technology

How do we capture these critical elements in an efficient process?

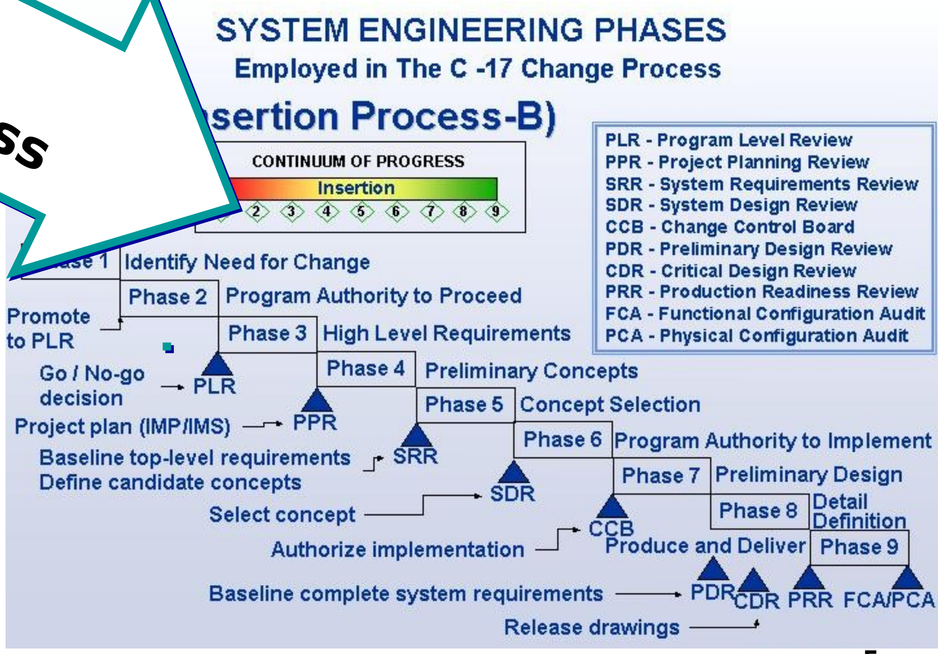
WE MUST CLOSE THE GAP BETWEEN…

DEVELOPMENT



How is readiness really defined?

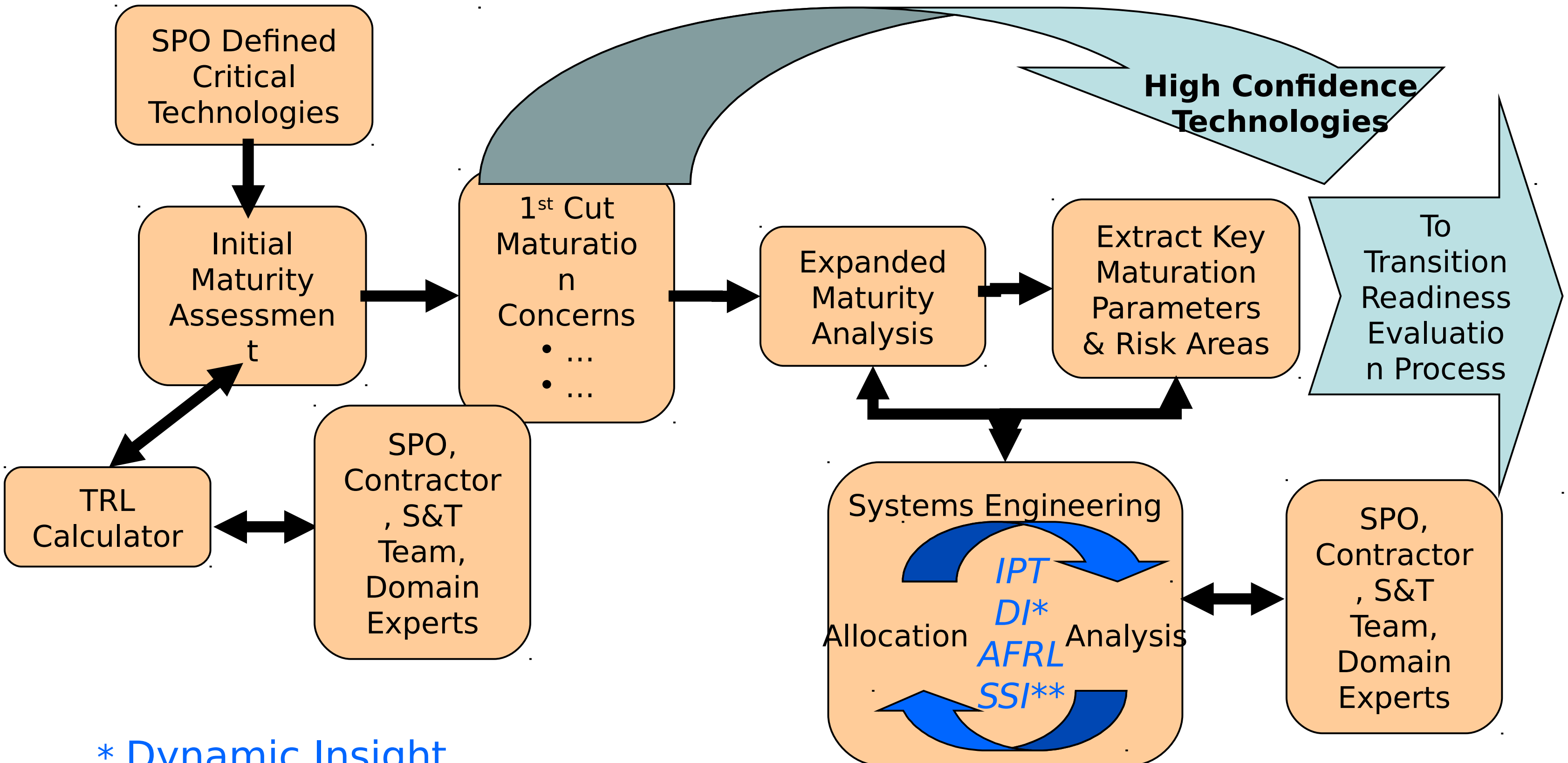
PRODUCTION



Ref: Boeing Technical Interface Meeting, with AFRL, 9 Dec 03

Candidate TRA Process – First Phase

Establishing Key Maturation Parameters – Where Do I Need To Focus?

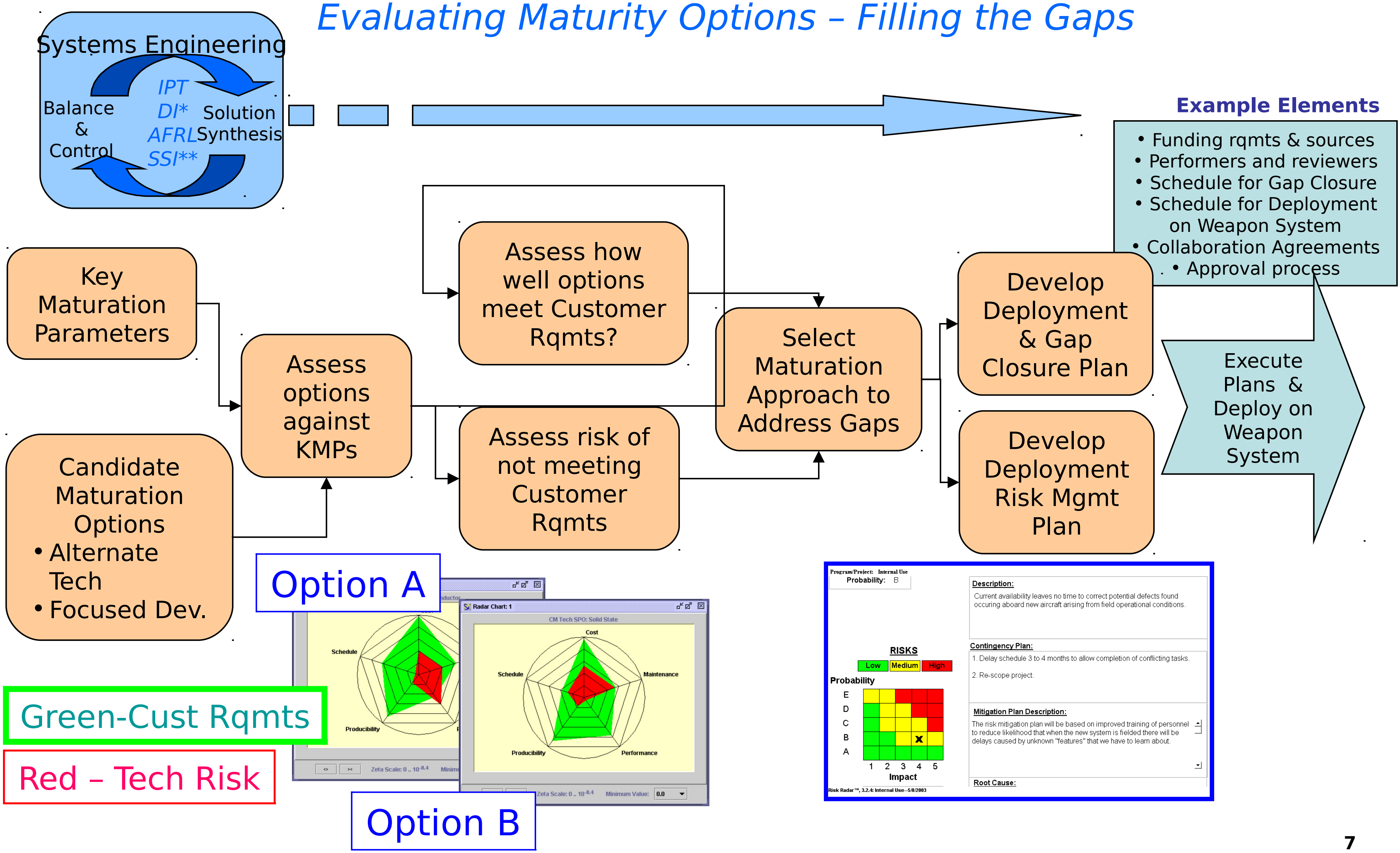


* Dynamic Insight

** AFRL SPO Support Initiative

Candidate TRA Process – Second Phase

Evaluating Maturity Options – Filling the Gaps



AFRL Developed TRL Calculator*

Main Menu | TRL Calculator | Beta Release Notes | PBT Calculator

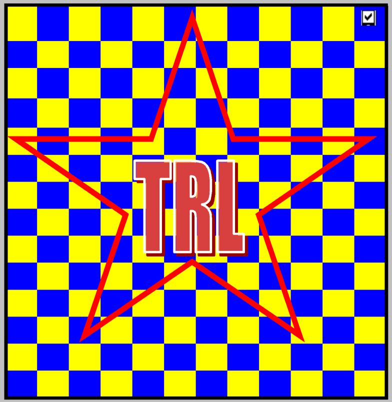
AFRL Hardware and Software TRL Calculator, Version 2.01

This worksheet summarizes the TRL Calculator results. It displays the TRL, MRL, and PRL computed elsewhere. You may select the technology types and TRL categories (elements) you wish to include here or on the Calculator worksheet. Choose Hardware, Software, or Both to fit your program. If you omit a category of readiness level, (TRL, MRL, or PRL) that calculation is removed from the summary. The box in front of each readiness level element is checked when that category is included in the summary.

You can enter program identification information here, too.
TRL documentation including discussions of TRL, MRL, and PRL is available from the Main Menu. There's also a Practice Based Technology calculator.

	Include Hardware Only
	Include Software Only
X	Include Hardware and Software

X	Use / Omit	Technology Readiness Level
X	Use / Omit	Manufacturing Readiness Level
X	Use / Omit	Programmatic Readiness Level



Summary of the Technology's Readiness to Transition

Program Name:

Program Manager:

Date TRL Calculated:

Overall TRL Achieved 9

Overall TRL is an aggregate TRL that includes contributions from each of the three readiness level elements checked above.

1	2	3	4	5	6	7	8	9

Green Level Achieved

TRL 9	MRL 9	PRL 9

Yellow Level Achieved

** Developed by Mr. William Nolte – AFRL/SN*

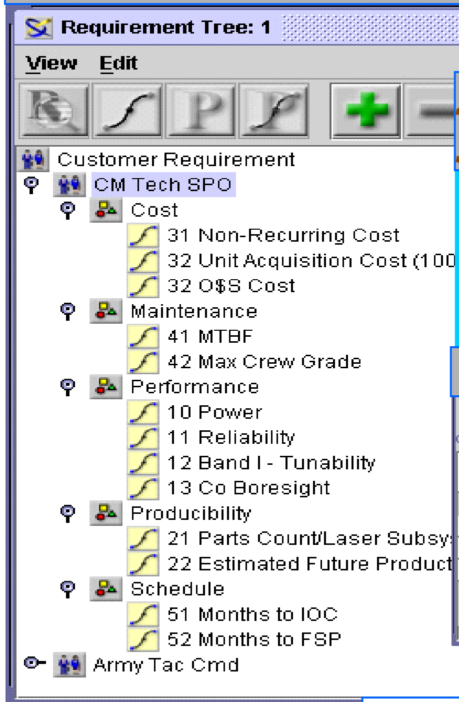
Example TRL 5 Criteria

H/SW Both	Ques Catgry	% Complete		TRL 5 (Check all that apply or use sliders)
B	T	100	☑	Cross technology effects (if any) identified and established through analysis
H	M	100	☑	Pre-production hardware available
B	T	100	☑	System interface requirements known
B	P	100	☑	System requirements flow down through work breakdown structure (systems engineering begins)
S	T	100	☑	System software architecture established
H	M	100	☑	Targets for improved yield established
S	T	100	☑	External interfaces described as to source, format, structure, content, and method of support
S	T	100	☑	Analysis of internal interface requirements completed
H	M	100	☑	Trade studies and lab experiments define key manufacturing processes
B	T	100	☑	Interfaces between components/subsystems are realistic (Breadboard with realistic interfaces)
H	M	100	☑	Significant engineering and design changes
S	T	100	☑	Coding of individual functions/modules completed
H	M	100	☑	Prototypes have been created
H	M	100	☑	Tooling and machines demonstrated in lab
B	T	100	☑	High fidelity lab integration of system completed, ready for test in realistic/simulated environments
H	M	100	☑	Design techniques have been defined to the point where largest problems defined
H	P	100	☑	Form, fit, and function for application addressed in conjunction with end user development staff
H	T	100	☑	Fidelity of system mock-up improves from breadboard to brassboard
B	M	100	☑	Quality and reliability considered, but target levels not yet established
H	M	100	☑	Some special purpose components combined with available laboratory components
H	P	100	☑	Three view drawings and wiring diagrams have been submitted
B	T	100	☑	Laboratory environment modified to approximate operational environment

AFRL Is Investing In a Tool For Assisting with the TRA

Formalizing Tech Readiness Assessment

1. Define Tech Maturity Rqmts



2. Decide Customer Satisfaction Criteria

- **Define Measures**
- **Establish Objectives**
- **Establish Thresholds**

3. Weigh Requirements

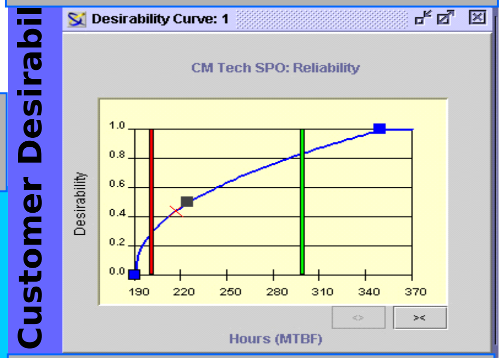
Type: Performance

Customer: CM Tech SPO

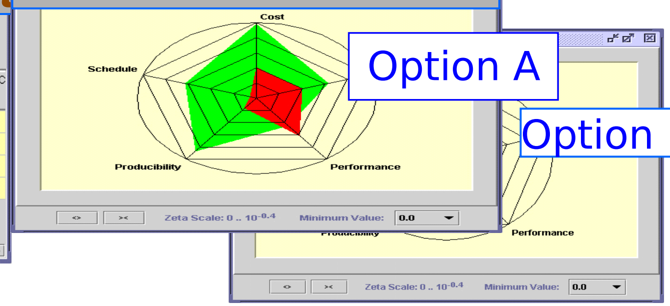
Requirement	Priority	How Measured	Objective	Lower Threshold	Upper Threshold	Weight
10: Power	Medium	watts	10	7		3.0
11: Reliability	High	Hours (MTBF)	300	200		2.0
12: Band I - Tunability	Medium	nm	1,000	600		2.0
13: Co Boresight	High	urad	50		120	1.0

4. Establish Trade Space

Customer Desirabil



5. Evaluate Alternatives



Dynamic Insight® is a commercially available from James Gregory Associates

Captures "Tech Readiness" And Maturation Concerns

Embodies The Systems Engineering Process

- ***Communication Tool For Stakeholders (SPO, Contractor, S&T)***
- ***Allows for Effective Trade-0ffs & Provides Traceability For Decisions***

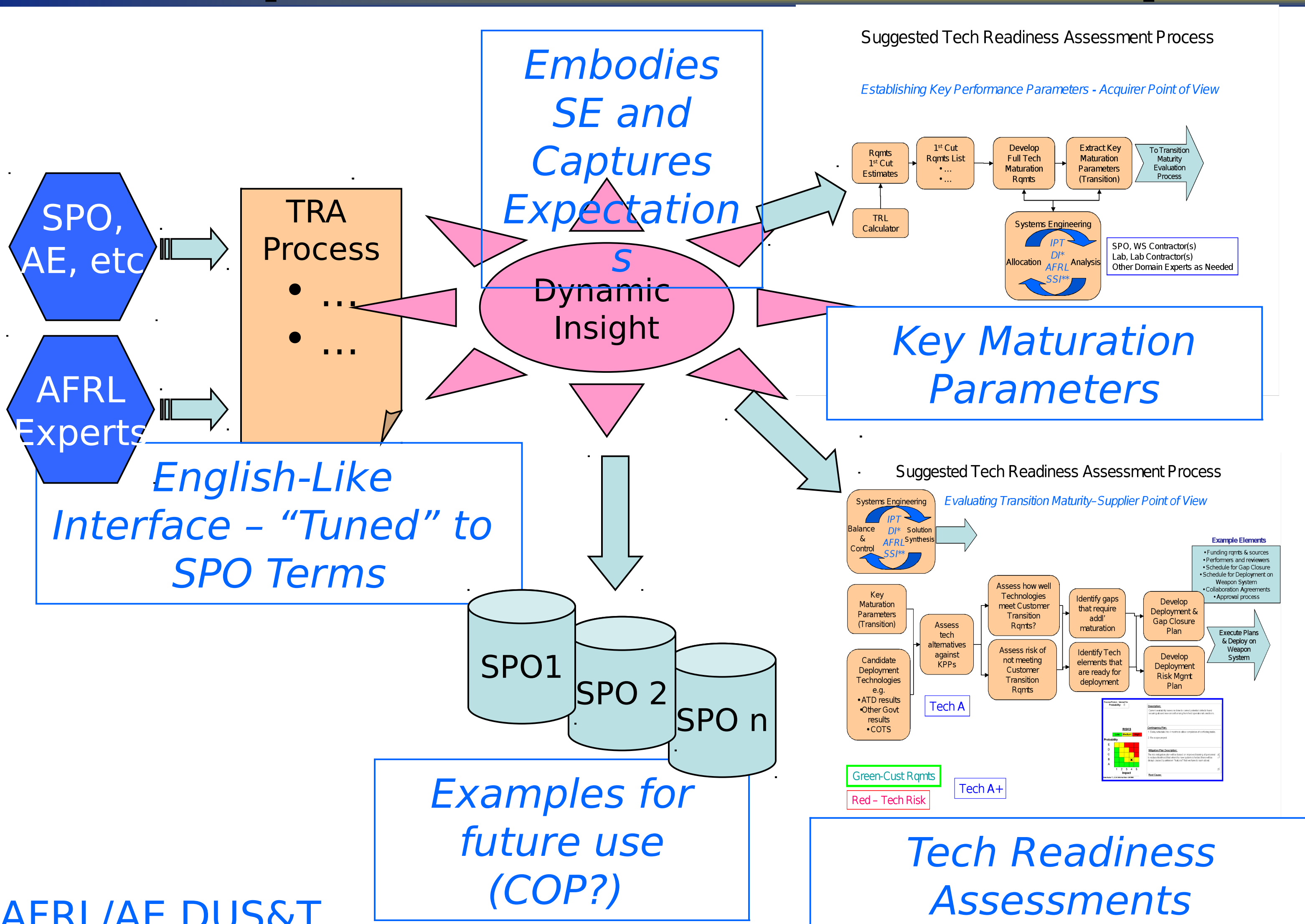
Summary

- The process for conducting TRAs does not appear to be well defined
- TRL's are not sufficient for defining the true readiness of a technology:
  - Good 1st cut self assessment
  - Satisfy management's need for a "go, no-go" number
  - Does not address production, sustainment, system unique issues/relationships, etc
- The time is right to establish a more analytical, self documenting approach for conducting Tech Readiness Assessments
  - Responds to pressure to implement Systems Eng. & Expectation Mgmt
  - Builds on ACE role
  - Commercial tool is available that can be tailored to this application
- AFRL/AE is making the investment to demonstrate the concepts in practice – with small set of select SPOs and "constructed" examples
- Opportunity exists for ACE community to contribute to and guide the implementation of the enhanced process and tools.

We would appreciate your input and guidance

Back Up Slides

TRA Tool for Acquisition and Tech Development*



• AFRL/AE DUS&T Program

Notional C-17 Technology Deployment Requirements

Custome C-17 SPO

Rq mt #	Customer	Requirement	Priority	How Measured	Objective	Lower Threshold	Upper Threshold	Type	Description	How tested	Objective Rationale
	C-17 SPO	Reduced Procurement Cost	High	Percent	30	12			Procurement cost of one C-17.		
	C-17 SPO	Reduced Life Cycle Cost	High	Percent Savings over Baseline Configuration	15	6					
	C-17 SPO	Durability	High	Number Life times of C-17	4	2					
	C-17 SPO	Supportability	Medium	Scale 1 - 5	5	4			c. Scale defined: ...d; 3=New tools or ... impact		
	C-17 SPO	Skills Required	High	Scale 1 - 5	5	3			Skills required to maintain new technology after insertion. Scale Definition: 1=Complete re- ... mal training required; ... required		Ideal situation is to replace old component with a component that requires no special skills, training, etc.
	C-17 SPO	MTBM	High	Hours					...rammed maintenance		
	C-17 SPO	Inspection	Medium	Scale 1 - 5	5	3		Maintainability	Scale Defined: 1=Inspection not possible; 3=Inspection by NDE methods only; 5=Inspection by NDE and visual.		
	C-17 SPO	Weight	High	Scale 1 - 5	5	3		Performance	Weight of new component compared to current component. Scale Definition: 1=Heavier than old component; 3=Same weight as old component; 5=Lighter than old component.		Ideal solution will be lighter than old component.
	C-17 SPO	Structural Arrangement	High	Scale 1 - 5	5	3			Overall structural arrangement must remain the same. Scale Definition: 1=Major modification ... new component; 3=Slight ... ired to install component; ... in replacement.		Ideal situation is a drop-in replacement.
	C-17 SPO	Strength	High	Scale 1 - 5	5	3		Performance	Scale Definition: 1=Reduced strength; 3=Same strength; 5=Better strength		Ideal situation is to improve structural strength.
	C-17 SPO	MTBF	High	Hours				Performance			Ideal component will have better MTBF than current component.
	C-17 SPO	Margin of Safety	High	Percent				Performance			
	C-17 SPO	Procurement Lead Time	High	Months				Producibility	Time between order placement and receipt of material		
	C-17 SPO	Industrial Base	High	Scale 1 - 5	5	3			Product availability and product reproducibility. Scale Definition: 5 =Multiple vendors with ... high process capability; 3= ... one dedicated line and high ... 2=material is available per ... ated line) and achieves ... ity control standards; 1 =		Ideal situation where product is a standard product line with adequate process controls.
	C-17 SPO	TRL	High	Level 1 - 9				Producibility	NASA Recognized TRL Levels.		
	C-17 SPO	MRL	High	Level 1 - 9				Producibility	Manufacturing Readiness Level		
	C-17 SPO	First Time Yield	High	Percent	100	95		Producibility	Product quality. Form, fit, and function.		
	C-17 SPO	Tooling Impact	High	Scale 1 - 5	5	3		Producibility	Scale Defined: 5=Fully understood at System Level to include cost impacts; 3=Partial understanding at system level ; 1=No		
	C-17 SPO	Insertion Date	High	P Number and or Date of Block				Schedule	The Aircraft number on which the technology can ... e expected to be ready for insertion.		
	C-17 SPO	Complete Process Documentation	High	Months prior to PDR					Process docmentation. (DPS/DMS).		
	C-17 SPO	Model Based Enterprise	High	Months prior to CDR				Schedule	Complete team must acquire 3-D data, control 3-D data, use 3-D, and inspect 3-D data		

Cost

Logistics Support

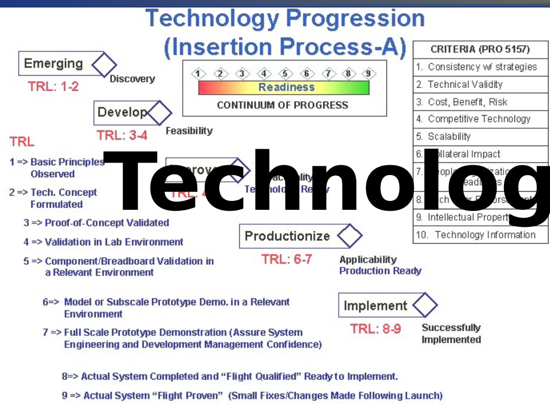
Maintainability

Performance

Producibility

Schedule

Proposed Platform for Change



Technology Transition Agreement


BOEING PROPRIETARY

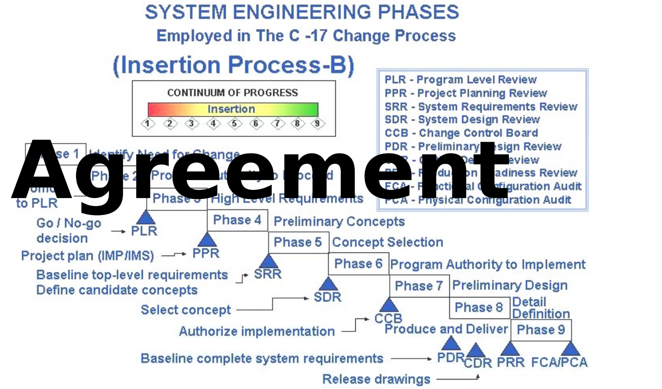
SAMPLE

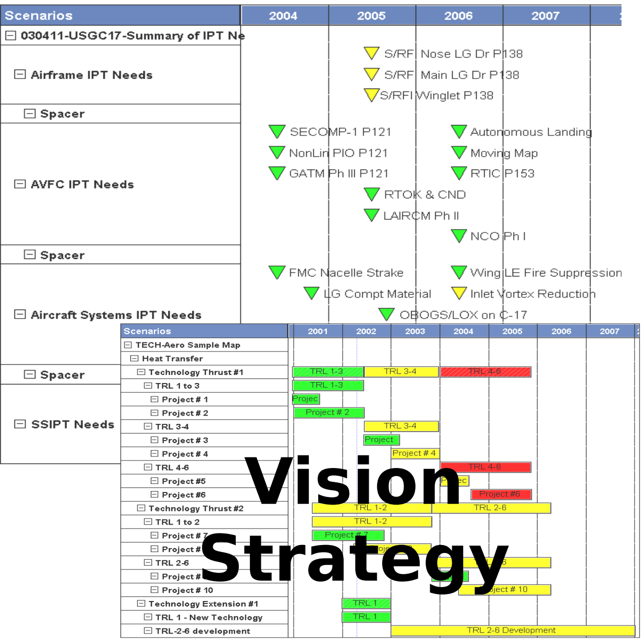
Technology Transition Agreement (TTA)

Non-corrosive Unobtanium Widget

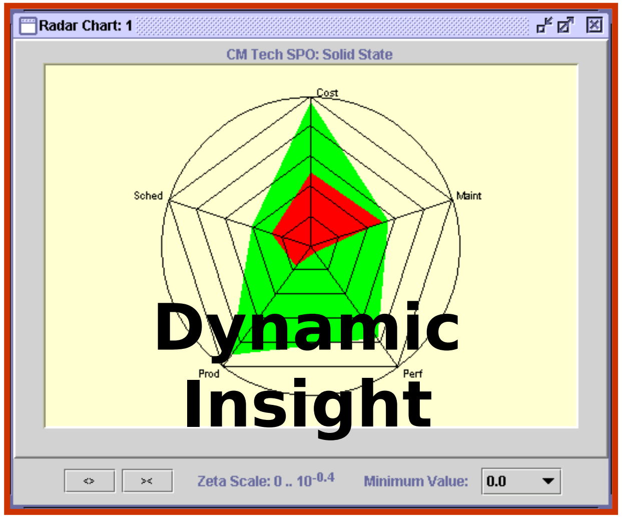
Concurrence:
Modify the list below to show concurrence from leaders in all participating organizations (L-Level Manager required, Director level desired, VP level optional).

Signature Name **PW Project Lead**	Signature Name **Adv. Programs Project Lead**	Signature Name **A&T Pgm IPT Project Lead**
Signature Name **PW Program Manager**	Signature Name **Adv. Programs Program Manager**	Signature Name **A&T Pgm IPT Program Manager**
Signature Name **PW Thrust Manager**	Signature Name **IDS NBF Management**	Signature Name **A&T Pgm IPT Director**

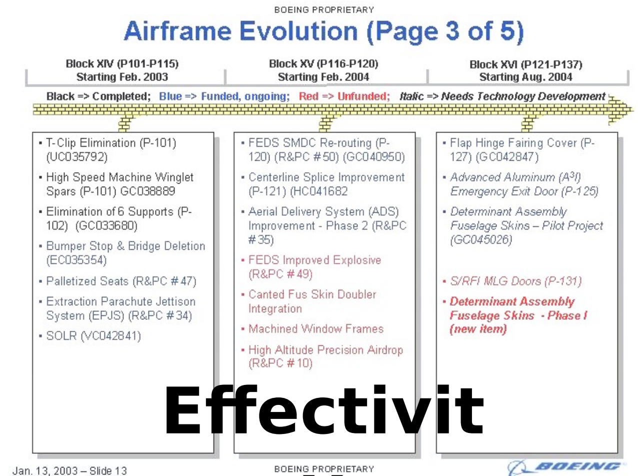




Vision Strategy



Dynamic Insight



Effectivity Roadmap

Ref: Boeing Technical Interface Mtg, with AFRL, 9 Dec 03

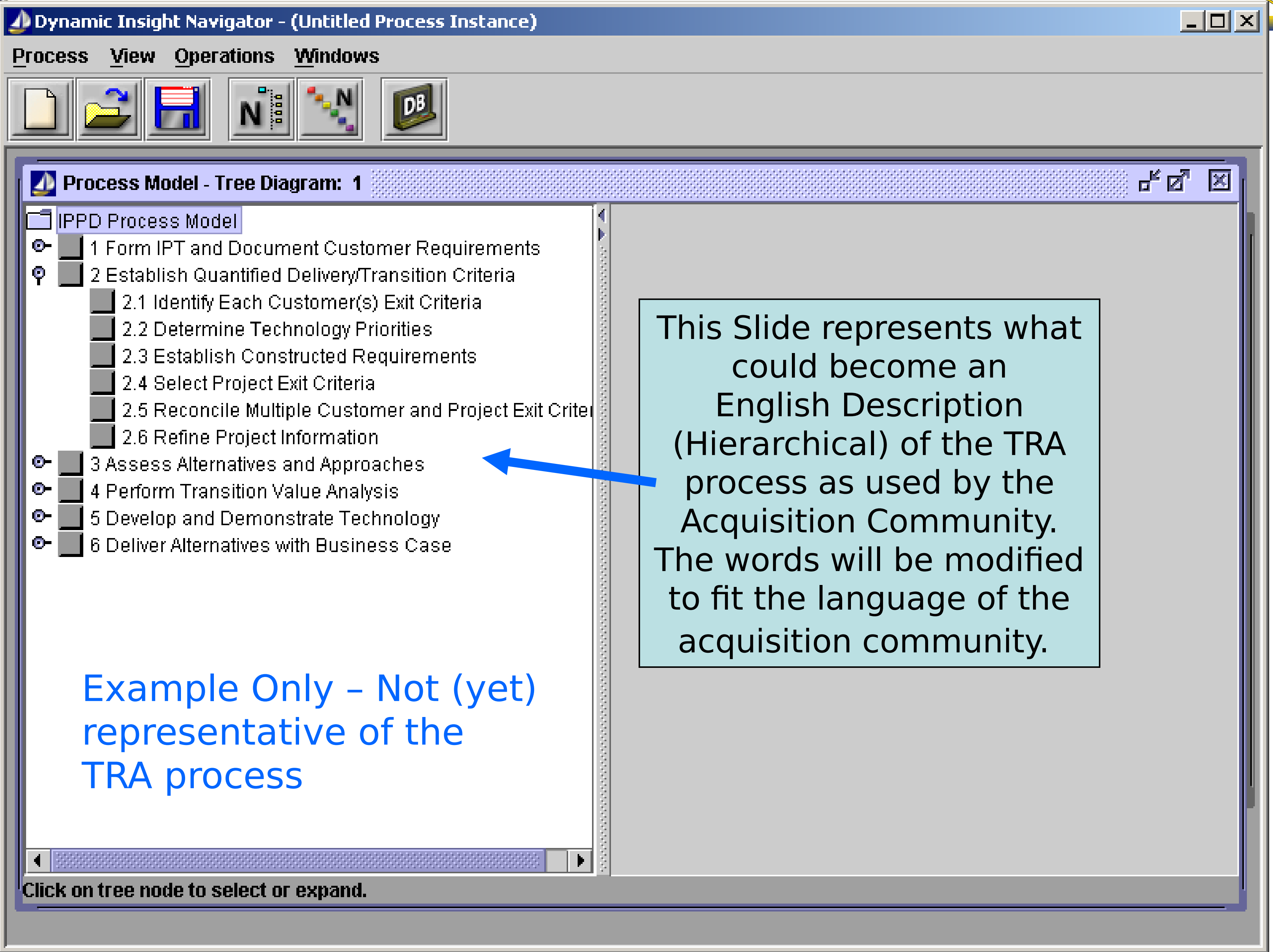
Multiple tools working together…

Example - TRL 4 Criteria

H/SW Both	Ques Catgry	% Complete		TRL 4 (Check all that apply or use slider for % complete)
B	T	100	✓	Cross technology issues (if any) have been fully identified
H	M	100	✓	Ad hoc and available laboratory components are surrogates for system components
H	T	100	✓	Individual components tested in laboratory/by supplier (contractor's component acceptance testing)
H	M	100	✓	Piece parts and components in a pre-production form exist
H	T	100	✓	M&S used to simulate some components and interfaces between components
S	T	100	✓	Formal system architecture development begins
B	P	100	✓	Customer publishes requirements document
B	T	100	✓	Overall system requirements for end user's application are known
B	P	100	✓	System performance metrics have been established
S	T	100	✓	Analysis provides detailed knowledge of specific functions software needs to perform
B	P	100	✓	Laboratory requirements derived from system requirements are established
H	M	100	✓	Available components assembled into system breadboard
H	T	100	✓	Laboratory experiments with available components show that they work together (lab kludge)
S	T	100	✓	Requirements for each function established
S	T	100	✓	Algorithms converted to pseudocode
S	T	100	✓	Analysis of data requirements and formats completed
S	T	100	✓	Stand-alone modules follow preliminary system architecture plan
H	T	100	✓	Hardware in the loop/computer in the loop tools to establish component compatibility
S	M	100	✓	Designs verified through formal inspection process
B	P	100	✓	S&T exit criteria established
B	T	100	✓	Technology demonstrates basic functionality in simplified environment

Providing English-Like Tool Interface

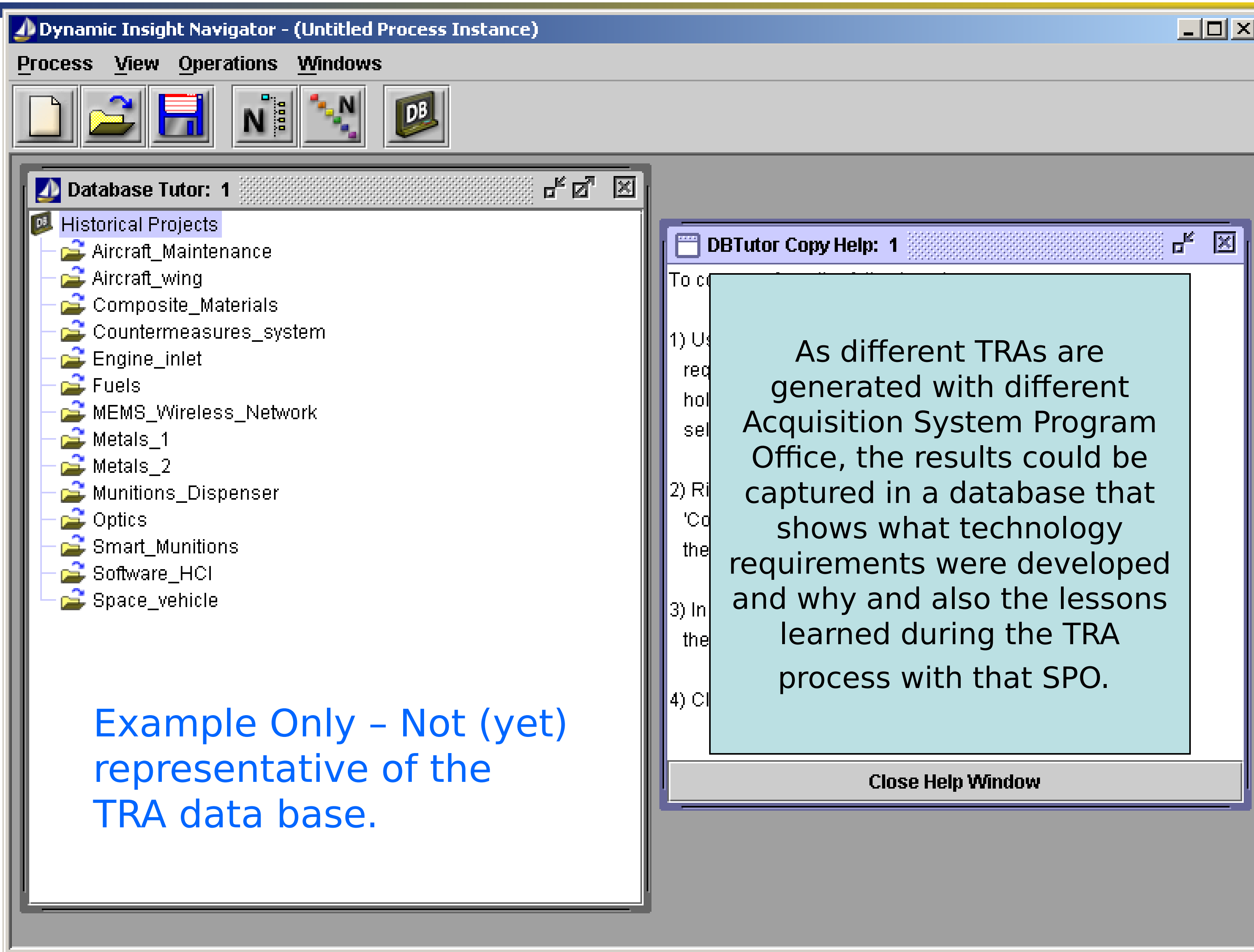
IPPD Navigator – for Dynamic Insight



This Slide represents what could become an English Description (Hierarchical) of the TRA process as used by the Acquisition Community. The words will be modified to fit the language of the acquisition community.

Example Only – Not (yet) representative of the TRA process

Capture TRA experience in database for future use



Example Only – Not (yet) representative of the TRA data base.

As different TRAs are generated with different Acquisition System Program Office, the results could be captured in a database that shows what technology requirements were developed and why and also the lessons learned during the TRA process with that SPO.